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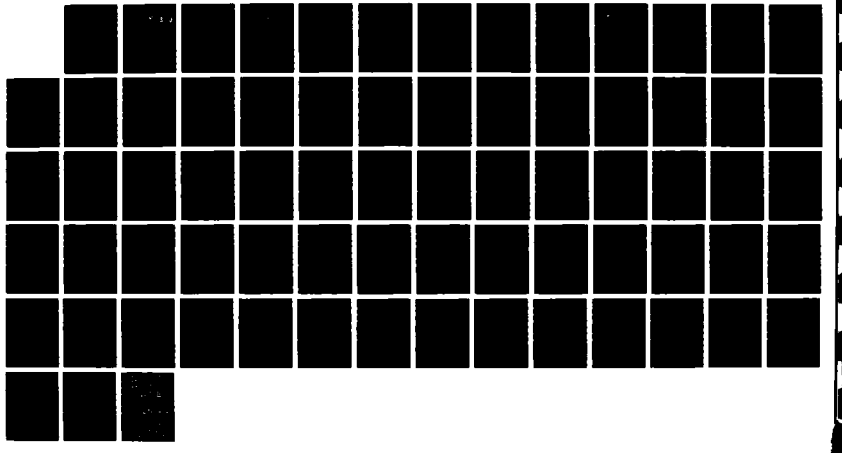

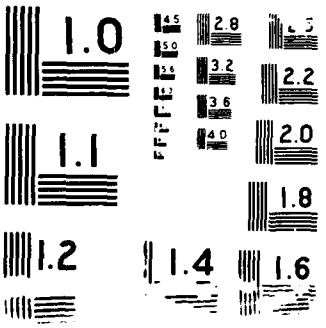
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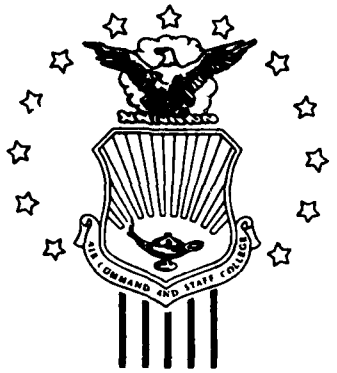


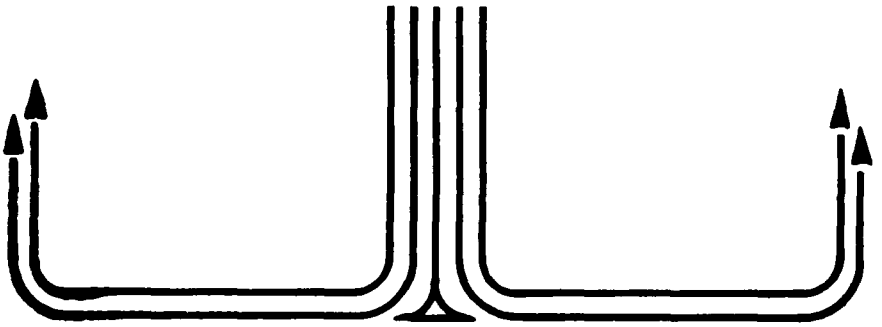
AIR COMMAND AND STAFF COLLEGE

STUDENT REPORT

INTRODUCTION TO
ARTIFICIAL INTELLIGENCE
PROPOSAL FOR AN ACSC ELECTIVE

Major William P. Nelson 88-1965

"insights into tomorrow"



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Submitted to the faculty in partial fulfillment of requirements for graduation.

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Documents the initial development of a 16-contact hour elective in artificial intelligence (AI). Demonstrates the need for the elective by examining planned DoD uses of AI. Follows the instructional systems development (ISD) process. Examines military, commercial, and academic sources on AI research and use. Presents recommended level of learning objectives, samples of behavior, and an annotated bibliography for each of six recommended lesson blocks. Includes recommendations for further course development by ACSC.

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PREFACE

Several people gave assistance to the author during this project. Major Del Tackett provided leads on several excellent references and related projects. Major Jim Gatewood, as the project advisor and sponsor, acted as a sounding board for ideas on which direction to take in developing the course. Lieutenant Colonel James Macey was very helpful in reviewing the project for adherence to the instructional systems development process. Classmates Betsy Rogers and Keith Snyder, as well as my wife Janice, all helped with references, proofreading, or moral support. I thank all of these individuals for their time and effort. They made completing the project easier and definitely contributed to its quality.

ABOUT THE AUTHOR

Major William P. Nelson was awarded a Bachelor of Science in Computer Science in 1974 by the United States Air Force Academy. In 1978 he was awarded a Bachelor of Science in Math by Auburn University at Montgomery. In 1980 he was a distinguished graduate at the Air Force Institute of Technology and was awarded a Master of Science in Computer Science. His masters thesis dealt with the combined use of pattern recognition and artificial intelligence techniques in problem solving.

Major Nelson has had a variety of duties dealing with the technical or professional education aspects of computers. He taught at the Air Force Institute of Technology in the Electrical Engineering Department as a Graduate Instructor. He served two years as the Course Director, Computer Resources Acquisition Course, AFSC Systems Acquisition School where he helped develop the course and recruit instructors for it. Major Nelson participated as a consultant on software quality assurance to the DoD Software Test and Evaluation Project (STEP) and authored a paper on the subject which was included in the report prepared by Georgia Institute of Technology. He also served as the Air Force representative to the Human Resources Task panel of the DoD Software Technology for Adaptable, Reliable Systems (STARS) project while stationed with the AFSC Systems Acquisition School. Major Nelson has assisted on several education projects beyond his teaching assignments. These include the critique of the first offering of the Management of Software Acquisition Course at Defense Systems Management College, acting as a technical reviewer for a computer aided instruction system developed at Electronic Systems Division, and serving as both a content and technique monitor on a contract to develop three computer acquisition courses.

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EXECUTIVE SUMMARY

Part of our College mission is distribution of the students' problem solving products to DOD sponsors and other interested agencies to enhance insight into contemporary, defense related issues. While the College has accepted this product as meeting academic requirements for graduation, the views and opinions expressed or implied are solely those of the author and should not be construed as carrying official sanction.

"insights into tomorrow"

REPORT NUMBER 88-1965

AUTHOR(S) MAJOR WILLIAM P. NELSON, USAF

TITLE INTRODUCTION TO ARTIFICIAL INTELLIGENCE - PROPOSAL FOR AN ACSC ELECTIVE

I. Purpose: To document the initial steps in the development of an elective course in artificial intelligence (AI) for Air Command and Staff College (ACSC).

II. Problem: The current and projected use of artificial intelligence (AI) techniques in both industry and the Department of Defense implies that Air Force leaders will increasingly encounter systems based on artificial intelligence capabilities. The content and structure of an ACSC in-house elective on artificial intelligence should be determined.

III. Development: The Instructional System Development (ISD) process is followed in establishing the base for an ACSC elective course in artificial intelligence. Chapter 1 introduces the project. It documents that two major defense efforts are aimed at advancing progress in the use of artificial intelligence. The Department of Defense includes AI-related topics among the top twenty technologies for which relative U.S. and U.S.S.R. status are tracked. From this is drawn the premise that Air Force leaders will encounter systems based on artificial intelligence

techniques with increasing frequency. Chapter 2 investigates what a prospective student needs to know. Military, commercial, and academic sources are examined for possible course topics. A prioritized list of sixteen possible topics is developed. Chapter 3 covers the expected knowledge level of an entering student. Air Force initiatives, Air Force Institute of Technology programs, and past ACSC projects are examined. The conclusion is drawn that ACSC students will have little or no knowledge of artificial intelligence. A final list of recommended course topics is presented. Chapter 4 describes the process used to develop lesson objectives and samples of behavior for a 16-hour course. These are given in Appendix A, broken down into the recommended six lesson blocks. Appendix B presents an annotated bibliography broken into recommended lesson references, possible student readings, and additional references. These are presented by lesson block.

IV. Recommendations: Chapter 5 discusses suggested steps for further course development. The following recommendations are made:

RECOMMENDATION #1: Complete the development of an ACSC elective course on artificial intelligence. Include six hours of instruction on expert and knowledge-based systems. Present two hours on each of the following topic areas: overview of artificial intelligence, natural language processing, machine vision, speech processing, and planning/problem solving/reasoning.

RECOMMENDATION #2: Send the initial set of level of learning objectives and samples of behavior to Air Force offices involved with artificial intelligence for review and comment. Request AFSC/DL assistance in developing an appropriate list of offices.

RECOMMENDATION #3: Use guest presentations on actual military artificial intelligence applications as part of the course.

RECOMMENDATION #4: Procure commercial artificial intelligence packages for the Z150-series microcomputers. Use them not only in course support, but in support of the ACSC staff and faculty.

RECOMMENDATION #5: Include a lesson or block of instruction on artificial intelligence in the core curriculum of all Air University programs. This could be as a separate topic or as part of a lesson or block on computer technology.

Chapter 1

INTRODUCTION

PURPOSE AND ORGANIZATION

This paper documents an ACSC research project which investigated the need for an elective course in artificial intelligence. This chapter documents the rationale for undertaking the project. It presents background information on the growth of artificial intelligence (AI). The importance of AI to the military and the United States Air Force is shown.

Chapters two through four document the employment of the instructional systems development (ISD) process. Air Force regulations require the use of this system (48:Ch 1). Steps one and two of the process, which document educational requirements and student needs, were completed and are discussed in chapters two and three. The approved project design document for this course envisioned completion through step three of the ISD process, development of objectives and tests. Some progress was expected on step four, plan and develop instruction outline. This limit was set because full development of a sixteen contact hour course (the usual length of an ACSC elective) would require more effort than allotted project time allowed. In actual execution, only part of ISD step three was completed. Information useful for step four was developed during the process. Chapter four documents these results. Lesson objectives and samples of behavior were developed and are documented in Appendix A. Recommended references and possible student readings for each lesson are presented in Appendix B. The fifth chapter summarizes the project. It also presents recommendations for further work on an ACSC elective course in artificial intelligence.

PROJECT RATIONALE

Problem Statement

The current and projected use of artificial intelligence (AI) techniques in both industry and the Department of Defense implies that Air Force leaders will increasingly encounter

systems based on artificial intelligence capabilities. What should be the content and structure of an ACSC in-house elective on artificial intelligence? The preceding sentences were the problem statement for this project. The remainder of this section will document the validity of the opening statement. This is done by examining some major Department of Defense projects.

Project FORECAST II

Project FORECAST II was a study directed in 1985 by the Secretary and Chief of Staff of the Air Force. It studied new technologies expected to have exceptional promise for future Air Force use. "The aim of Project FORECAST II, simply stated, is to provide operational Air Force commanders a menu of the 'art of the possible' in future warfare" (44:1). Project FORECAST I, a predecessor study, helped shape basic US Air Force doctrine (54:126). FORECAST II should have the same far reaching effects. According to Lieutenant General William E. Thurman, Commander of Aeronautical Systems Division, "[The project] will revolutionize the way the Air Force carries out its mission in the 21st century, guaranteeing continued technological supremacy over any potential adversary" (33:32).

FORECAST II identified artificial intelligence as a "key component" in 32 of the 7Ø project initiatives. Additionally, one initiative dealt wholly and specifically with an AI technique - knowledge-based systems (41:ii,2; 45:PT-36.1 - PT-36.17). Many of the project's goals cannot be accomplished without using artificial intelligence (33:32). AI is essential to FORECAST II and to defense systems of the future.

FORECAST II will significantly impact the future of the Air Force. The same level of significance applies to the key underlying artificial intelligence technologies. If FORECAST II is to provide a menu of future possibilities to Air Force commanders, they need some basic level of knowledge in these underlying technologies. FORECAST II establishes artificial intelligence as a topic of concern to future Air Force leaders.

Strategic Computing Program

In 1983, the Defense Advance Research Projects Agency (DARPA) began a program in computer technology judged critical to the national defense. "The overall goal of the program is to provide the United States with a broad base of machine intelligence technology that will greatly increase our national security and economic power" (51:1Ø). "The program begins by building on a selected set of intelligent computing capabilities that are ripe for development in the near term" (51:14). This project is the Strategic Computing Program.

The Strategic Computing Program is important to this paper for two reasons: the importance of the program itself and the underlying technologies. In its initial report, DARPA states that military tasks are outstripping the abilities of commanders and members (51:3-5). The Strategic Computing Program (SCP) is offered as the solution to this problem (51:6-7). The Secretary of Defense supports this in singling out SCP for specific mention in his most recent annual report to Congress (50:250). The program, then, is vital to Defense. However, all of the major projects proposed in the original report are dependent upon artificial intelligence technologies (51:22,25,28). In fact, the program is pictured as a pyramid of basic computer technologies which will provide capabilities needed for future military systems (51:11; 18:50). One entire level of the pyramid is labeled "intelligent functional capabilities" in the original report (51:Figure 4.1). The program is expected to "move toward a completely new generation of machine intelligence technology" (51:7). This will be a technology rich in applied artificial intelligence (18:51; 50:250).

The Strategic Computing Program is a major defense program. It will develop the technologies necessary for defense systems of the future. The program calls for expanded development of artificial intelligence techniques and requires their use in building future military systems. Military managers of the future will need to know something of these techniques if they are to be effectively used.

Direct Strategic Importance to United States Defense

The Department of Defense keeps track of what it terms the twenty most important basic technology areas to defense. It tracks the relative standing of the United States and the Union of Soviet Socialist Republics (USSR) in these twenty areas. In the Secretary of Defense's report to Congress for the fiscal year 1988/89 budget, two of the twenty technologies are computer related. These are "computers and software" and "robots and machine intelligence" (50:245). Both areas include artificial intelligence methods.

In the area of computers and software, DoD has a Defense Software Initiative which will ". . . [improve] our ability to provide reliable, cost-effective computer software for defense systems" (50:247-248). An important part of this initiative is the use of the Ada programming language. Ada "will be used in over 130 defense systems, in the flight software for the NASA Space Station, and for the NATO Command and Control systems" (50:247-248). At least some Ada-based projects will use expert system techniques (41:Appendix C). Rome Air Development Center (RADC) of Air Force Systems Command (AFSC) is also exploring the development of a Knowledge-Based Software Assistant. "[It will]

demonstrate the use of AI techniques in the development and maintenance of large, complex software-intensive weapon and support systems" (41:8,Appendix C). The Secretary of Defense's report shows that the United States is superior to the USSR in the area of computers and software, with superiority increasing (50:245). Artificial intelligence will be used in maintaining this status.

Robots and machine intelligence is the second AI-related area among the twenty most important basic technologies. The United States is shown as superior to the USSR in this area (50:245). The Secretary specifically discusses the Strategic Computing Program as the major effort which will help maintain this position (50:250). As discussed earlier in this report, artificial intelligence is a key component of the SCP.

Summary of Rationale

Artificial intelligence is expected to be critical to future United States defense capabilities. Two major defense efforts are aimed at advancing progress in the use of artificial intelligence. The Department of Defense includes AI-related topics among the top twenty technologies for which relative U.S. and U.S.S.R. status are tracked. From this was drawn the premise that Air Force leaders will encounter systems based on artificial intelligence techniques with increasing frequency. The question then becomes, what do leaders need to know about these systems? This project explores this by addressing the need for and content of an ACSC artificial intelligence elective.

Chapter 2

ANALYSIS OF SYSTEM REQUIREMENTS

DESCRIPTION OF STEP AND APPROACH

The first step in the ISD process, analyze system requirements, requires documenting what a prospective student needs to know. In a training course, the first part of this step would require analyzing some system or procedure. The system's purpose, personnel requirements, subcomponents and similar topics are studied. Data on tasks, standards, technical orders, opinions of experts and system users, and similar areas are gathered. The course designer "[determines] if there really is a need for instruction and, if so, precisely what instruction is needed" (48:5). For the educational needs of an ACSC elective, the equivalent task involved gathering data on whether a field grade manager or commander needed to know anything about artificial intelligence (AI), and if so, what. As documented in Chapter 1 of this report, AI will be vital to future defense systems. Its application to national defense will increase capabilities. In fact, our ability to perform tasks envisioned for the future may depend on AI. The remainder of this chapter will therefore concentrate on the topical content for an AI elective for ACSC.

The pool of expected students consists of officers attending Air Command and Staff College. The analysis of educational need must deal with a field grade officer (most likely Air Force) in this position. The question to be answered is: "What is there about any given technology that such a student most needs to know?" The student is likely to occupy "mid-level" command or management positions upon graduation. This would equate to a squadron level in an operational unit; a divisional or directorate level within a laboratory or headquarters. As a starting point for researching such a student's educational needs, the author postulated that the information about a given technology most useful to this student would be tied to its expected use by the military. Data gathered should in some sense be validated by balancing it against the general development of AI within industry and academia.

With this approach, the preliminary search concentrated on how the Air Force and the Department of Defense will use artificial intelligence. Two reports proved to be excellent sources of data. One documents major Air Force Systems Command efforts and the other documents the interests of the Defense Advanced Research Projects Agency. The reports describe major AI research and development. They represent a military base for educational needs on artificial intelligence for an ACSC elective. The second source of possible topics consisted of information on the expected commercial use of artificial intelligence in the United States. The thought was that if the commercial sector is employing an AI technology, managers (or commanders) are more likely to encounter it. To balance the search for topics, a tertiary set of sources was established. This set consisted of books on artificial intelligence. The relative importance given to these sets of sources is indicated by their being designated primary, secondary, and tertiary sources. For discussion purposes the sets are labeled as military, commercial, or academic sources. [Note that this nomenclature actually refers to the content of the source rather than its actual author.]

In the following discussion, a section is dedicated to each of the military, commercial or academic groupings. First, the perceived importance of each source and its reason for selection is discussed. Topics found in each source are then discussed. When possible, the topics are labeled as either application or development. An application label indicates current or expected near term use of the AI technology. A development label indicates a need for more research and development or application further in the future. Finally, a summarization and ranking of topics gleaned from all the sources is presented.

MILITARY SOURCES

Air Force Research in AI

In December 1983, the Vice Chief of Staff of the Air Force (General Skantz) initiated tasking to develop an AI Research and Development Master Plan. This tasking recognized the "tremendous potential of AI to address Air Force mission requirements" (41:ii). HQ AFSC/DL developed the plan for the Air Force. In 1985 the same office established an AI Investment Review Board, which developed a Five-Year Investment Plan. These two plans were combined in 1987 into the Air Force Systems Command Artificial Intelligence Research and Development Investment Plan (41:--). The primary objective of the program established by this plan is "to achieve the most efficient and effective development, application, and transition of AI technology to the operational commands" (41:iii). The program addresses objectives

to be achieved in the next five years. The program represents a major thrust of Air Force AI efforts. It was accepted as documenting those aspects of AI most likely to be encountered by mid-level Air Force managers in the near future.

The Investment Plan presents data on "thrust areas" that different AFSC organizations are pursuing (41:Appendix C). Additionally, the plan discusses technology development topics. "[These] are a consolidation of technology needs/limitations identified . . . during the preparation of [the] plan" (41:15). Course topics were chosen from both areas. Topics were labeled "application" if multiple thrust areas required the technology. An application label was also assigned if working or prototype systems employing the technology were planned. If the plan explicitly labeled an area as a technology development topic (41:15-17), it was treated as such for course development. In selecting topic areas, related thrusts or development efforts were combined under a single applicable topic. This led to a list that does not correspond one-to-one with development topics as listed in the plan. For example, both knowledge base maintenance and knowledge engineering are discussed. The generic topic knowledge engineering covers both. Table 1 lists the complete sets of possible topics developed from the plan.

Application Topics	expert systems
	image processing
	knowledge-based systems
	multiprocessor architectures
	natural language understanding
	planning
	speech recognition
	speech understanding
Development Topics	AI system development
	computing approaches for AI
	explanation in expert systems
	knowledge engineering
	qualitative reasoning
	reasoning under uncertainty

Table 1. Possible Topics Based on AF Research

Defense Advanced Research Project Agency AI Efforts

A second major source for possible topics was a report by the Defense Advanced Research Project Agency. The report (51:--)

documents the Strategic Computing Program, which was discussed in Chapter 1. As noted there, the SCP will provide the US with an indispensable base of technologies for defense systems. Many of the technologies involved fall under the heading of AI. At its inception in 1983, the program hoped to demonstrate significant military capabilities within 10 years (37:95). As of 1987, contracts for work relating to the program ". . . are spread among almost 50 companies and more than two dozen universities" (18:50). The Secretary of Defense supports the program in his annual report to Congress for FY89 (50:250). Congress' own Office of Technology Assessment considers the program important to continued U.S. pre-eminence in computer technology (37:9-10,93-94). The Strategic Computing Program was treated as a prime source of possible course topics.

The original Strategic Computing Program structure and goals can be envisioned as a pyramid structure. In this structure, the program goals are at the apex supported by military applications. These are supported in turn by a technology base (51:11; 37:93-95). Later program descriptions suggest there are six tiers of technology within the program, with each level dependent on advances in the level below. The lower five of these six levels represent the technology base (18:50). Within both of these descriptions is a level labeled variously as "intelligent functional capabilities" (51:11; 37:95) or "machine intelligence" (18:51). This level of the SCP technology base provided several course topics. The report notes that some of the technologies are generic in nature. They will find application in multiple systems and will be developed as "modular intelligent subsystems" (51:12). These areas were treated as application topics. All other areas from the machine intelligence level were treated as development topics. Another entire level of the technology base deals with architectures for AI (51:11; 37:95; 18:51). This was selected as a development topic area. Table 2 lists the topics thus selected, divided into application and development groups.

Application Topics	expert systems natural language processing speech recognition vision
Development Topics	architectures for AI design and manufacturing use integrated interfaces planning

Table 2. Possible Topics Based on DARPA Research

COMMERCIAL EFFORTS

Congressional Office of Technology Assessment R&D Report

The Office of Technology Assessment (OTA) of the Congress of the United States published a report in 1985 on trends in research and development on information systems. One of the areas addressed was artificial intelligence (37:13-14,87-107). While the report discusses the possibility that AI capabilities may have been "oversold" (37:13,87-88) it also notes the promise of AI. There have been notable successes in applying AI to real-world problems with intense commercial interest in at least three areas (37:88-89). OTA also reports that information technology research and development in general has several goals. Among these are supporting national defense, enhancing national prestige, and supporting civilian agency missions (37:3-4). ". . . Future U.S. leadership in computer science will depend on an aggressive program of research in [the AI] field" (37:13). Given this premise, the OTA report was selected as representative of important commercial AI efforts.

The OTA report dedicates a case study to artificial intelligence (37:87-107). This case study presents a commercial perspective on the use of artificial intelligence. According to the study, commercial AI products introduced in the past 25 years have been of three types: expert systems, natural language processing programs, and image or vision processing systems (37:87). Current commercial interest is also strongest for natural language data base interfaces, experts systems, and robot vision systems (37:88). These areas are therefore considered to be application topics for possible course inclusion. The report discusses several other areas in which further research is needed: symbolic computation, pattern recognition, knowledge representation, and machine learning (37:97-100). These topics are labeled as development topics. Table 3 summarizes possible course topics based on the OTA report.

Application Topics	expert systems
	natural language processing
	vision (or image) processing
Development Topics	knowledge representation
	machine learning
	pattern recognition
	symbolic computation

Table 3. Possible Topics Based on Office of Technology Assessment Report

AI Colloquium

In 1983 a colloquium was held to discuss the pros and cons of artificial intelligence (14:--).

> [It brought] together four groups of people: one group to supply the academic perspective, another group to represent the hard core, financially oriented people, a third to represent the commercial research and development people who can look at the questions from both sides, and a fourth to represent solutions-oriented people, who use Artificial Intelligence, sometimes without admitting it, because there is a job to be done (14:preface).

The sponsors judged the affair to be quite successful based on attendance and the "exciting views" and "heated differences of opinion" that took place. The AI Business: The Commercial Uses of Artificial Intelligence, published in 1984, contains edited transcripts of the colloquium (14:--). The first three parts of The AI Business are applications oriented. Each of these parts was reviewed for possible course topics.

Part I deals with expert systems and discusses two commercially acceptable expert systems and one experimental expert system in detail. It is evident that some commercial success has been achieved in expert systems. It is also apparent that creating expert systems is no simple task. Some systems take as many as 30+ man-years of effort with at least five man-years being the minimum investment required (14:26). Even this may not result in a system that evolves beyond the laboratory (14:25-29). So while expert systems have shown success, it is also an area requiring further advancement of the science (14:37-39,79-90). Nevertheless, the discussion in the book documents that expert systems have enjoyed some commercial success. The implication is clear that they will continue to be an area of commercial interest. Expert systems are therefore indicated as a course topic for an ACSC AI course.

Part II of the book is entitled "Work and Play." It discusses using artificial intelligence to aid someone in performing their tasks. Papers in this section discuss an engineer's apprentice that aids in integrated circuit layout (14:111-119) and a project for a programmer's apprentice that would ". . . provide every programmer with a support team consisting of intelligent computer programs" (14:121-132). One commonality is dependence on and use of a task-specific knowledge base (14:115-116,125-126). A third paper discusses "intelligent advisory systems" (14:133-148). These are not full expert systems but would have an English language interface. These systems can be classified knowledge-based systems [see glossary].

A fourth paper in the section deals specifically with natural language interfaces (14:149-161). While a discussion of other AI topics occurs, expert systems, natural language processing, and knowledge-based systems are the most common threads. They are extracted as possible topics.

Robotics is the title of the third part of the book. The first paper (14:179-203) discusses the lack of a widely accepted definition for robotics. However, it indicates fairly wide commercial usage and groups commercial robots into three generations. Third-generation robots (which are programmable and generally attached to computers) appear to fall into the AI category. The second paper (14:205-222) dwells mainly on the idea that vision systems will make robotics a major commercial use of artificial intelligence. It also suggests that artificial vision was the first AI capability to be widely used on the factory floor. The third paper in the section (14:223-228) takes the position "the current approach to Artificial Intelligence is dominated by the clever use of brute force" and the I in AI is a myth (14:223). However, the paper's author also notes that his company "plans to be a major participant in factory automation" (14:228). The company is "bullish on intelligent robots and intelligent sensors" (14:228). While the papers raise some questions on commercial viability of AI, current application is occurring and more is expected. The two common topics are robotics and vision.

The AI Business: The Commercial Uses of Artificial Intelligence, examines AI from a business perspective. It suggests more research is needed and also cautions against overselling AI. Some successes have been achieved. Commercial applications are occurring and more can be expected. A study of the papers presented exposes many AI areas, but a few stand out either through application or as a basis for multiple systems. These are candidates for inclusion in an AI elective for ACSC They are summarized in Table 4.

Application Topics	expert systems knowledge-based systems natural language processing robotics vision

Table 4. Possible Topics Based on AI Colloquium

Other AI Applications Information

In 1985, a book on artificial intelligence was published that ". . . [concentrated] on actual applications or the research that has or will directly lead to applications" (1:7). Applications in Artificial Intelligence is an edited collection of papers from a multitude of authors from academia, industry, and government (1:--). It's editor, Stephen J. Andriole, was ". . . formerly Director of the Defense Department's Advanced Research Projects Agency's [DARPA's] Cybernetics Technology Office where he was also a program manager" (1:xvii). When the book was published in 1985, Mr. Andriole was President of International Information Systems, Incorporated. Given the editor's credentials, and those of the contributors (1:xvii-xxiv), the book is used as a third source on commercial applications of AI.

The book is divided into six parts. The editor states that Parts II through VI ". . . all represent particular perspectives about applied AI and discuss many of the best-developed tools and techniques of applied AI" (1:xiv). Therefore, expert systems, natural language processing, and robotics (corresponding to parts II, III, and V of the book) are selected as candidate course topics. Part IV of the book contains articles dealing with AI techniques as applied to the general problems of information management. The first article in the section deals with "smart information management" (1:247), and the second describes a "smart" tool for "dynamically interacting with and managing information" (1:248). These are not full expert systems, but can be classified as knowledge-based systems. Part VI of the book is called "Problem Solving." The papers deal with ". . . areas that have benefited from a number of smart systems which crosscut . . . . the development and application areas [discussed in other parts of the book]" (1:423). Knowledge-based systems is again an applicable label. Because of direct discussion in various papers, (as well as the title of Part VI itself), problem solving is also selected as a candidate topic. Since the book deals with applied artificial intelligence, all selected topics from it are labeled as such. Table 5 summarizes them.

Application Topics	expert systems knowledge-based systems natural language processing problem solving robotics

Table 5. Possible Topics Based on AI Applications

ACADEMIC SOURCES

Finally, several texts on artificial intelligence were reviewed to see what "academia" considered to be part of AI. While there are many possible sources, concentration was on those texts which claimed to give a general treatment or overview of AI.

The publication dates of the selected sources span the time period 1974 through 1984. Of the texts reviewed, the most comprehensive was the three volume Handbook of Artificial Intelligence (2:--; 3:--; 4:--). These volumes represent ". . . a comprehensive survey of AI that stripped away jargon, filled out assumptions, presented essential problems, and simply described solutions" (4:xiii). The volumes are the contributed works of over seventy researchers, academicians, and practitioners (2:ix; 3:ix; 4:xi). The next most comprehensive coverage was from William B. Gevarter, Office of Aeronautics and Space Technology, National Aeronautics and Space Administration (6:--). His book is based on three reports developed for NASA which provided an overview of AI (6:v). Four additional books were selected as representative of the field in general (11:--; 8:--; 12:--; 13:--).

All selected books were reviewed, and a preliminary list of topics was made. A topic was included if one of the sources included it as a major topic of discussion. This required a chapter or major section of the book dedicated to the topic. A final list of topics was created using three critera. First, a topic was put on the final list if both of the most comprehensive sources (see discussion above) covered it. Second, a topic was put on the final list if three or more of the sources covered it. Finally, the list was refined by combining related topics under a single generic heading. The final list of possible course topics based on academic input is given in Table 6.

computer languages (for doing AI)
expert systems
game playing
knowledge-based systems
mathematics and logic
natural language processing
planning and problem solving
search and solution
speech processing
vision

Table 6. Possible Topics From AI Texts

SUMMARY OF POSSIBLE TOPICS

Table 7 is a summary of topics, in priority order, for possible inclusion in an AI course. In combining Tables 1 through 6, it was necessary to do some "technical leveling" to match terms among the sources used. With many terms in the AI realm there are no absolute, authoritative definitions. Different sources may label related or identical topics with variant terms. Within reasonable limits the topics given in Table 7 combine related topics and terms. They are also consistent with the definitions included in the glossary provided at the end of this paper.

Multiple occurrences of topics in Tables 1 through 6 was the primary basis for final topic selection shown in Table 7. The four highest priority topics occurred in at least five of the tables. The secondary topics occurred at least three times in the previous tables. Relative priority among primary and secondary topics was assigned based on the application and development classifications made earlier. The ten tertiary topics in table seven were designated with a priority of seven if they occurred twice, and a priority of eight if they occurred once. Relative ranking was not done among priority seven or priority eight topics. Expected course coverage of these tertiary topics would probably be by "survey", with no detailed coverage.

Grouping	Topic	Priority
Primary	expert systems	1
	natural language processing	2
	knowledge-based systems	3
	machine vision	4
Secondary	speech processing	5
	planning/problem solving/reasoning	6
Tertiary	development issues	7
	hardware for AI	7
	mathematics and logic	7
	robots and automation	7
	computer languages for AI	8
	design and manufacturing (use in)	8
	game playing	8
	machine learning	8
	pattern recognition	8
	search and solution techniques	8

Table 7. Final Candidate Topic List

Chapter Three

DETERMINATION OF EDUCATION REQUIREMENTS

DESCRIPTION OF STEP AND APPROACH

The second step of instructional system development is determination of education or training requirements. First, the knowledge or skill level of the perspective student is determined. The requirements derived in step one of the ISD process are compared to this level. "The difference between what [the students] have and what they should have determines what instruction is needed" (48:5).

Data on the knowledge level of Air Force field grade officers in the area of artificial intelligence are not readily available. However, the probable knowledge level of the "typical" student expected for this class can be inferred from looking at several related sources. These sources all deal with the knowledge level of Air Force personnel in some area of computers. One of the sources specifically addresses ACSC students. Each source is discussed. Inferences are drawn on the probable knowledge level of ACSC students with respect to artificial intelligence.

This chapter will conclude by comparing the knowledge level of ACSC entrants with the topics derived in Chapter 2. The result is the suggested course content for an ACSC elective in artificial intelligence.

EXPECTED KNOWLEDGE LEVEL OF STUDENTS

Project Bold Stroke

Project Bold Stroke is an Air Force project designed to address the need for education about software management and the impact of software on weapons systems (46:--; 43:--; 42:--; 31:--). The Secretary of the Air Force and the Chief of Staff of the Air Force stressed the project's importance in a joint memo. In part, they stated (42:--):

> . . . Air Force operational readiness can be improved significantly through increased management attention and understanding of the dominant role software plays in weapon systems effectiveness. The study confirmed that our software expertise has not kept pace with the rapid spread and technological advances of computer-based weapon and information systems. . . .
>
> To improve our management capabilities, we will provide Air Force leaders with education opportunities to increase their understanding of software development and general awareness of the importance of software and computer-based technology in fielding new operation capabilities.

The project addresses educating personnel at all levels. A new software management course was instituted for general officers and senior executives. All new generals will see software management in their orientation course (42:--). Pre-commissioning, professional military education, technical training programs, and college programs are to address this need also (42:--; 31:29).

Project Bold Stroke documented a lack of knowledge in software and computer based technology in 1985. As of early 1987, articles were still being published on efforts to fill this void (31:--). We can infer from Project Bold Stroke conclusions that Air Force personnel's knowledge of artificial intelligence is correspondingly low. This inference is based on the relative "newness" of AI as an applied technique. Mr. Thomas E. Cooper, Assistant Secretary of Defense for Research, Development, and Logistics supports this. Guidance for ROTC scholarships sponsored under Project Bold Stroke requires coverage of

> . . . higher order material, directed to expertise in expert systems, including rule based languages, learning systems, program generators and program transformations, and the design and development of associated architectures which can exploit these software technologies (40:--).

Some of these areas are artificial intelligence topics (e.g. expert systems and learning systems). Others often employ artificial intelligence techniques (e.g. rule based languages and program generators).

The original Bold Stroke report did not directly address artificial intelligence. It has been directed that some efforts undertaken as a result of the project should. This implies Air Force personnel are not knowledgeable in this area.

Air Force Institute of Technology AI Efforts

Efforts at the Air Force Institute of Technology (AFIT) also provide data on Air Force knowledge levels in artificial intelligence. The author was a student and then graduate instructor at AFIT from August 1978 through June 1981. During that time there were no course offerings specifically on artificial intelligence. Since that time AFIT has established courses for both continuing education and graduate programs.

In 1984, AFIT established a continuing education course on AI (57:--; 58:--; 33:35; 49:4-60). Graduate offerings were established in about the same time frame (58:--; 38:--). Development material on the originally perceived needs of students for these courses is not available (57:--). According to Lieutenant General Thurman, Commander of Aeronautical Systems Division, the continuing education course was developed when ASD recognized the need for personnel trained in AI. Educated personnel were essential to support developments critical to the future of the Air Force (33:35). Current course descriptions provide further insight. AFM 50-5 describes Fundamentals of Artificial Intelligence, the continuing education course.

> [The course] is an introduction to the technology of Artificial Intelligence (AI). The education goal of the course is to provide the student detailed information on AI fundamentals, AI programming techniques, and a working knowledge of how to build an expert system (49:4-60).

An AFIT Department of Electrical Engineering brochure describes the graduate course of study in artificial intelligence.

> . . . This sequence generates the capability to design and develop expert systems using artificial intelligence techniques. As part of the sequence, the student will gain an indepth [sic] understanding of problem solving, search techniques, blackboard models, knowledge representation techniques, and automated planning. Expertise will be developed in AI programming languages (LISP and PROLOG) (38:17).

How does this relate to the knowledge level of ACSC students with respect to AI? When General Thurman's article was published in April 1987, it estimated that 120 Air Force personnel had taken the course. An additional 100 DoD personnel had received modified versions of the course (33:35). AFM 50-5, which documents formal training available through Air Force channels, indicates this is the only available Air Force short course. While training may be available from many other sources, the

implication is that not many Air Force personnel are receiving training in AI. The author's own experience with AFIT graduate programs leads him to expect that fewer than 100 students have taken the AI graduate sequence. Few ACSC students are likely to have been exposed to these courses.

Survey of ACSC Student Knowledge of Microcomputers

A recent ACSC research project surveyed the class of 1987 about their knowledge of microcomputers (55:--). We can make inferences from this report about student knowledge of AI. The project found the vast majority of ACSC students were aware mission effectiveness could be increased with the use of microcomputers. Still, the project concluded that a course covering some aspects of microcomputers was still required. Recommended topics included acquisition and procurement, management of hardware and software, hands-on orientation to hardware and software, and issues facing users developing applications. The need to stress management aspects was highlighted (55:21-22). Another point made is that any course developed will need constant review due to changing technology (55:21,30). What judgments can we make with respect to artificial intelligence?

The project dealt with microcomputers. A need for education or training was identified in basic areas of computer technology. This is despite the fact that 75% of the class owned personal computers and 65% used them on previous jobs (55:14). As with Bold Stroke, this project did not specifically address artificial intelligence. It does show a need for instruction in basic computer technology topics. If students (and in this case, specifically ACSC students) are not knowledgeable in basics, they will not be knowledgeable in advanced areas. ACSC students are not likely to be knowledgeable about artificial intelligence.

Summary

No sources directly addressing the knowledge level of ACSC students in the field of artificial intelligence are available. However, a major Air Force initiative documented the need for training in basic software and computer technology topics. Project Bold Stroke also addresses a need to include AI techniques in sponsored ROTC scholarships. AFIT has only recently begun instruction in areas of AI. Their courses all address a basic knowledge level. Not many ACSC students are likely to have received training from either of these sources. An ACSC research paper documented a need for an ACSC elective in basic microcomputer technology topics. This suggests knowledge level in advanced topics such as artificial intelligence will also be low. The author concludes that most ACSC students will have no knowledge of artificial intelligence topics.

EDUCATION REQUIREMENTS

Chapter 1 concluded with a list of possible topics for an ACSC elective in artificial intelligence. This chapter has documented that ACSC students typically will have no knowledge of artificial intelligence. The conclusion is that all of the topics listed in Table 7 should be included in the elective. However, this must be tempered against available class time.

The typical ACSC elective course includes 16 contact hours. If all the topics in Table 7 were included, only a very shallow coverage of each would be likely. The priorities assigned to the topics should be taken into account. Based on this and the author's experience in creating and teaching computer related courses, the top six topics are recommended. An exception is made in the areas of expert systems and knowledge-based systems. The conceptual underpinnings of these two areas are very similar. If both can be included in a course, they should be combined for instructional purposes. The author recommends a combined priority equal to the highest of the two based on the importance given them in the sources researched. Finally, an additional topic area is suggested. Research to this point indicated that students for this course would have little or no knowledge of AI. An introduction covering what AI is and why it is important is recommended for the course. This topic is added to those selected from Table 7. All priorities are adjusted accordingly. Table 8 presents the final recommendation on what an ACSC elective on artificial intelligence should cover.

Topic	Priority
overview of artificial intelligence	1
expert and knowledge-based systems	2
natural language processing	3
machine vision	4
speech processing	5
planning/problem solving/reasoning	6

Table 8. Final Recommended Topic List

Chapter 4

DEVELOPMENT OF LESSON OBJECTIVES AND REFERENCES

Once the education and training requirements for a course have been determined, objectives and tests are developed. Step three of instructional systems development (ISD) provides guidance on how this is accomplished (46:6; 47:Ch 3 - Ch 5). The normal process requires writing a level of learning (e.g. knowledge, comprehension, application) objective. The educator then develops samples of behavior for each objective. Each sample of behavior leads to a corresponding criterion objective through the addition of conditions and measurable criteria of achievement. Test items are then developed from these criterion objectives to complete the step (47:Ch 3). Only part of step three was accomplished for this project.

The creation of objectives, samples of behavior, criterion objectives, and test items for a full 16-hour elective proved to be more than allotted project time allowed. The author chose to complete all suggested lessons through objectives and samples of behavior. Air Force guidance suggests that objectives should normally be written prior to conducting research for lesson content. However, it also notes "research [accomplished during the lesson planning process] may justify a decision to modify an objective . . ." (47:6-1). In the author's personal experience with developing lessons on new technology, this often happens. Research for possible lesson development was therefore conducted in parallel with the development of objectives. The remainder of this chapter describes the thoughts that guided the effort.

The major considerations were the purpose and audience of the course. According to the ACSC electives handbook, the electives program "[enables students] to pursue courses in selected areas of special interest and need." The students "... come from a variety of assignments, represent a broad spectrum of job specialties, and vary considerably in military experience and formal education" (39:i). The introduction of this paper demonstrated a very real need for knowledge of artificial intelligence. Other chapters showed that most ACSC students will have a low knowledge of AI. A list of recommended topics was generated. In writing objectives for these topics, some further refinement was necessary.

The refinement was a matter of asking, what exactly does an ACSC student need to know about the topics? Should the course produce a student capable of implementing AI technology? Or is just a general knowledge level on the part of the student desired? One of the main points of Project Bold Stroke could be paraphrased to say that without Air Force personnel knowledgeable about computer software, we will not accrue the full benefits of the technology (46:1; 17:47-48). A recent Air War College paper on Bold Stroke specifically recommended making sure Air Force personnel appreciate the potential of the technology (52:21). In general, Air Force personnel must be technically literate to perform effectively. Managers (or Air Force leaders) must know what technology can and cannot do to use it effectively (56:14-15; 2Ø:--; 53:18-29,42-45). This was the major line of reasoning used to develop lesson objectives and samples of behavior.

The secondary guidance used to develop lesson objectives was the planned military uses of artificial intelligence. This means that although military, business, and academic sources all covered a given topic, more weight was given to concerns of the military uses. The Air Force and Department of Defense programs discussed in earlier chapters were used as the source of planned uses. This helped limit lesson objectives to something that could reasonably be covered in a 16-hour elective.

The author tried to develop lesson objectives geared to showing a student what AI can and cannot be expected to do. The exact coverage would favor military over civil applications. Research for lessons was conducted in conjunction with development of objectives. Beyond following this general track, the author used the lesson development process recommended by Air Force publications (48:6; 47:--). Actual objectives and samples of behavior produced are contained in Appendix A. Useful references found during research (including information on AI software packages for microcomputers) are documented in Appendix B.

Chapter 5

RECOMMENDATIONS FOR FURTHER DEVELOPMENT

DISCUSSION

This project has laid the base for further development of an elective for ACSC students on artificial intelligence. Chapter 1 introduced the project and documented that AI is of utmost importance to national defense. Chapter 2 presented research and documented the possible topics for an artificial intelligence course. Chapter 3 showed that newly arrived ACSC students will have a low knowledge level. It refined the list of topics from possible to recommended. Chapter 4 documented the development of lesson objectives and samples of behavior. These are presented by lesson in Appendix A. References for each lesson are presented in Appendix B. Several recommendations are now made for continuing the development.

As noted in chapter 4, the author strongly feels that the course should stress probable military applications of AI. Additionally, the strengths and weaknesses of the individual technologies should be stressed. In doing this, those technologies most likely to be implemented or most widely used should be stressed over those of less immediate utility. From this viewpoint, the most important of the recommended topics is the introduction to what AI is and its general utility to the military. But of the individual technology areas, the most important is expert and knowledge-based systems. The artificial intelligence research and development plan developed by Air Force Systems Command envisions expert systems as the AI technology most likely to have near term payoff. These technologies also underlie the major systems envisioned by the Strategic Computing Program. The author recommends six hours of instruction on expert and knowledge-based systems. Two hours of instruction should be provided on each of the other five topics in Table 8.

The objectives and samples of behavior presented in Appendix A are based on solid research, but still only represent the views of a single individual. Air Force offices working on artificial intelligence applications should be asked to comment on them. This will provide some level of validation and help make the course responsive to Air Force needs. The material could be sent

to AFSC/DL, OPR for the AI research plan referenced in this report, with a request for assistance. Alternatively, organizations listed in the appendices of the research plan could be contacted directly.

Any course developed should expose students to "real" applications to the extent possible. To accomplish this, personnel working on AI projects could be invited as guest lecturers. Again, the appendices to the AFSC AI research plan provide possible sources. An additional method of providing exposure is to obtain commercial AI packages for the Z15Ø-series microcomputers. Several packages are available at a reasonable cost (see Appendix B) and Z15Ø microcomputers are spread throughout the school. The students could be given a chance to actually interact with AI packages. This could be done during class hours or on an after hours basis. Alternatively, class demonstrations could be used. An additional benefit of this approach would be that any acquired packages would be available for possible application by ACSC staff and faculty.

The final recommendation deals with other possibilities for instruction on AI. Given the mandate for AI presented in this paper, some thought should also be given to including a block of instruction in the ACSC core curriculum. This could be done as a separate lesson or as part of a lesson on computer technology. A copy of this research should also be forwarded to appropriate offices within other schools at Air University for consideration. Too often in the past, computer technology has been poorly employed by the military. This happens at least partly because our leaders have not been given the opportunity to stay technically current. Artificial intelligence is widely expected to have a major impact on the future. Our future military capabilities and technological advantage over adversaries are dependent upon it. Air University can play an important role in preparing today's and tomorrow's leaders by offering instruction on this technology.

SUMMARY OF RECOMMENDATIONS

RECOMMENDATION #1: Complete the development of an ACSC elective course on artificial intelligence. Include six hours of instruction on expert and knowledge-based systems. Present two hours on each of the following topic areas: overview of artificial intelligence, natural language processing, machine vision, speech processing, and planning/problem solving/reasoning.

RECOMMENDATION #2: Send the initial set of level of learning objectives and samples of behavior to Air Force offices involved with artificial intelligence for review and comment. Request AFSC/DL assistance in developing an appropriate list of offices.

RECOMMENDATION #3: Use guest presentations on actual military artificial intelligence applications as part of the course.

RECOMMENDATION #4: Procure commercial artificial intelligence packages for the Z15Ø-series microcomputers. Use them not only in course support, but in support of the ACSC staff and faculty.

RECOMMENDATION #5: Include a lesson or block of instruction on artificial intelligence in the core curriculum of all Air University programs. This could be as a separate topic or as part of a lesson or block on computer technology.

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86. Goto, Yoshimasa, and Anthony Stentz. "Mobile Robot Navigation: The CMU System," IEEE Expert, Volume 2, Number 4 (Winter 1987), pp. 44-54.

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101. Reisman, Sorel. "AI's Promises Now Haunt It," IEEE Software, July 1987, p. 92.

102. Retelle, John P., LtCol, USAF and Mike Kaul. "The Pilot's Associate - Aerospace Application of Artificial Intelligence," Signal, June 1986, pp. 100-105.

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GLOSSARY

Author's Note: Almost all of the following definitions are direct quotations from the indicated sources. Quotation marks are not shown. When the definition is modified or adapted this is noted by use of brackets [...] or appropriate comment. The majority of the definitions are from Artificial Intelligence & Expert Systems Sourcebook by V. Daniel Hunt (10:--), with other references used when they provided a definition closer to the use in this paper.

artificial intelligence. The subfield of computer science concerned with developing intelligent computer programs. That includes programs that can solve problems, learn from experience, understand language, interpret visual scenes, and, in general, behave in a way that would be considered intelligent if observed in a human (10:52).

computer vision. Perception by a computer, based on visual sensory input, in which a symbolic description is developed of a scene depicted in an image. It is often a knowledge-based, expectation-guided process that uses models to interpret sensory data. Used somewhat synonymously with image understanding, scene analysis, and machine vision (10:74).

domain. A topical area or region of knowledge. Medicine, engineering, and management science are very broad domains. Existing knowledge systems provide competent advice only within very narrowly defined domains (10:92).

expert system. A computer program that contains both declarative knowledge (facts about objects, events, and situations) and procedural knowledge (information about courses of action) to emulate the reasoning processes of human experts in a particular domain (10:104). [see knowledge-based system and knowledge system]

game playing. [Adapted definition from indicated source.] An area of research that deals with the ability of computers to play games. In this century some of the earliest writings and efforts on information science and artificial intelligence dealt with game playing. Two primary reasons for this interest were that games provided a structured task and did not appear to require large amounts of knowledge (12:113-114).

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image processing. Transformation of an input image into an output image with more desirable properties, such as increased sharpness, less noise, and reduced geometric distortion (10:130).

knowledge-based system. A program in which the domain knowledge is explicit and separate from the program's other knowledge. A computer program that applies specialized knowledge to the solution of problems. An expert system is a knowledge-based system that is intended to capture the expertise of human domain experts (10:147). [see expert system and knowledge system]

knowledge engineering. The AI approach focusing on the use of knowledge (e.g., as in expert systems) to solve problems (6:62).

knowledge system. A computer program that uses knowledge and inference procedures to solve difficult problems. The knowledge necessary to perform at such a level plus the inference procedures used can be thought of as a model of the expertise of skilled practitioners. In contrast to expert systems, knowledge systems are often designed to solve small, difficult problems rather than large problems requiring true human expertise (10:152). [see expert system and knowledge-based system]

machine learning. A research effort that seeks to create computer programs that can learn from experience. (10:165) A learning machine, broadly defined, is any device whose actions are influenced by past experiences (64:vii).

machine vision. See computer vision.

multiprocessor. A computer that can execute 1 or more computer programs employing 2 or more processing units under integrated control of programs or devices (10:175).

natural language processing. [...] The ability of a computer to process the same language that humans use in normal discourse (27:225). Processing of natural language (e.g., English) by a computer to facilitate communication with the computer or for other purposes, such as language translation (10:179).

pattern recognition. [...] The idea of matching input from the environment with symbolic representations of patterns (e.g., visual objects or speech utterances) stored in the system (37:97).

planning. [...] Planning means deciding on a course of action before acting. A plan is, thus, a representation of a course of action (4:115).

problem solving. Problem solving is the process of developing a sequence of actions to achieve a goal (4:115).

qualitative reasoning. [An] attempt to represent and reason about the qualitative behavior, structure and function of spatial and temporal objects and the process of change they undergo. [It] aims at computer-based understanding of real systems in the physical world, enabling, for example, the computer to understand the behavior, structure, and function of a bicycle in ways similar to those of the average ten-year-old (41:17).

reasoning. The process of drawing inferences or conclusions (10:215).

robotics. The branch of artificial intelligence research that is concerned with enabling computers to "see" and "manipulate" objects in their surrounding environment (10:220).

search. The process of trying different actions in a system until a sequence of actions is discovered that will achieve an acceptable solution or goal state (10:231).

speech processing. [As used in this paper, the combined application of speech recognition and speech understanding, especially when combined into a system.]

speech recognition. Recognition by a computer (primarily by pattern matching) of spoken words or sentences (10:240). [see speech understanding]

speech synthesis. Developing spoken speech from text or other representations (10:240).

speech understanding. The use of artificial intelligence methods to process and interpret audio signals representing human speech (10:240). [The] change of perspective in speech recognition [from matching acoustic patterns to interpreting] acoustic signals in light of knowledge about syllables, words, and sentences, about the rules of conversation, and about the subject under discussion - is often referred to as the change from speech recognition to speech understanding (2:326). [see speech recognition]

symbolic computation. [The manipulation of] symbols that represent object, concepts, and qualities, as well as symbols that represent numbers or quantities, which are the focus of traditional computation (37:97).

vision. See computer vision; see image processing.

APPENDICES

APPENDIX A - Level of Learning Objectives and Samples of Behavior

APPENDIX B - Suggested Lesson References

APPENDIX A

LESSON BLOCK: Introduction to Artificial Intelligence

LEVEL OF LEARNING OBJECTIVE #1:

Know what artificial intelligence is.

Samples of Behavior:

Define artificial intelligence.

Describe the major characteristic expected of a computer program or application that is "artificially intelligent."

List techniques or areas of study that are considered to be areas of artificial intelligence.

Select computer techniques normally considered to fall within the definition of artificial intelligence from a list of techniques.

Provide an example of a problem, which if solved by a computer, would require the computer or program involved to display artificial intelligence.

Name an AI application area when given a description of it.

LEVEL OF LEARNING OBJECTIVE #2:

Comprehend why artificial intelligence is important to the Air Force and the Department of Defense.

Samples of Behavior:

Explain why artificial intelligence is crucial to future defense systems.

Give examples of future capabilities in defense systems that will require the use of artificial intelligence.

Explain the role of artificial intelligence in maintaining the United States technical lead over the USSR and in world computer technology.

APPENDIX A

LESSON BLOCK: Expert and Knowledge-Based Systems

LEVEL OF LEARNING OBJECTIVE #1:

Comprehend the similarities, differences, and fundamental structures of expert and knowledge-based systems.

Samples of Behavior:

Explain the interaction between the basic elements of an expert system.

Explain the interaction between the basic elements of a knowledge-based system.

Summarize the primary difference(s) of expert and knowledge-based systems.

Identify the fundamental elements of an expert or knowledge-based system if given a description of one.

Identify and define the types of knowledge necessary for an expert or knowledge-based system.

Give examples of successful expert or knowledge-based systems, to include the application area and what the systems accomplish.

LEVEL OF LEARNING OBJECTIVE #2:

Comprehend what issues are important to a planned use of expert or knowledge-based systems.

Samples of Behavior:

Explain the advantages that may be gained from the application of expert or knowledge-based systems.

Explain the current shortcomings of expert and knowledge-based systems.

Summarize the conditions that should exist before expert or knowledge-based systems are used as an approach to solving a problem.

Given a problem description explain why an expert or knowledge-based system solution approach would or would not be appropriate.

APPENDIX A

LESSON BLOCK: Expert and Knowledge-Based Systems (Continued)

LEVEL OF LEARNING OBJECTIVE #3:

Understand the basic concepts of knowledge representation.

Samples of Behavior:

Explain what knowledge engineering is.

Given a data base problem involving knowledge representation and a technique chosen for it, explain why the technique would or would not be appropriate.

Identify an area of knowledge representation in which further research is needed and explain why the research is necessary.

Explain how knowledge representation supports the implementation of expert and knowledge-based systems.

APPENDIX A

LESSON BLOCK: Natural Language Processing

LEVEL OF LEARNING OBJECTIVE #1:

Know what natural language processing is and how it can be accomplished.

Samples of Behavior:

Define natural language processing.

Given a description of a process or program, state whether or not it involves natural language processing.

List common approaches to natural language processing.

Identify an approach to natural language processing given its description.

Give an example of a natural language processing application.

LEVEL OF LEARNING OBJECTIVE #2:

Understand how natural language processing is employed in "normal" processing and in conjunction with other artificial intelligence techniques.

Samples of Behavior:

Given a computer application describe how natural language processing could be used to support it.

Give an example of a current natural language application.

Summarize the advantages or gains normally attributed to the use of natural language processing.

Give an example of problems or shortcomings in current natural language applications.

Identify areas of natural language processing considered to require further research to ensure more useful application.

APPENDIX A

LESSON BLOCK: Machine Vision

LEVEL OF LEARNING OBJECTIVE #1:

Know the basic concepts behind machine vision.

Samples of Behavior:

Given a concept basic to machine vision, define it.

Give an example of machine vision application or system.

Given a set of definitions and a set of terms common to machine vision, match them.

Given two machine vision concepts or methods, describe how they are related.

LEVEL OF LEARNING OBJECTIVE #2:

Understand how machine vision supports other technologies and applications.

Samples of Behavior:

Given a technology or example, describe how machine vision might be used in conjunction with it.

Explain commonly noted weaknesses of machine vision applications.

Given a combination of machine vision and a second technology, explain why it is or is not a good combination.

Give a current example of applied machine vision technology.

APPENDIX A

LESSON BLOCK: Speech Processing

LEVEL OF LEARNING OBJECTIVE #1:

Know the basic concepts and techniques of speech processing.

Samples of Behavior:

Given a term central to speech processing, define it.

List different methods of speech processing.

Describe the difference between connected and unconnected speech.

Given a method of speech processing, explain the basic concept of how it works.

Give an example of speech processing.

Given a description of a speech processing method, identify the method.

LEVEL OF LEARNING OBJECTIVE #2:

Understand the current limitations of speech processing.

Samples of Behavior:

Given a speech processing application considered to be beyond the capability of current technology, explain why it is.

Give an example of an area of speech processing requiring further development before practical application can be achieved.

Given an example of a current speech processing application, predict what conditions could cause required usage to exceed system capabilities.

APPENDIX A

LESSON BLOCK: Planning/Problem Solving/Reasoning

LEVEL OF LEARNING OBJECTIVE #1:

Know the basic concepts of planning, problem solving, and reasoning with respect to artificial intelligence.

Samples of Behavior:

Define basic terms used in planning, problem solving, and reasoning.

List past or planned applications of planning, problem solving, or reasoning and identify which is represented.

Given a description of a solution to a problem, decide whether planning, problem solving, or reasoning is the applied method.

Given a list of terms and definitions common to planning, problem solving, or reasoning, match them.

APPENDIX B

LESSON BLOCK: Overview of Artificial Intelligence

RECOMMENDED LESSON REFERENCES

1. Andriole, Stephen J. "AI Today, Tomorrow, and Perhaps Forever," Signal, June 1986, pp 121-123.

2. Gevarter, William B. Artificial Intelligence: Expert Systems, Computer Vision, and Natural Language Processing. Park Ridge, New Jersey: Noyes Publications, 1984.
   "Artificial Intelligence - What It Is," pp 3-7. Good overview with presentation of the "onion model" of artificial intelligence by see reference 3. below.

3. -----. Intelligent Machines: An Introductory Perspective of Artificial Intelligence and Robotics. Englewood Cliffs, New Jersey: Prentice-Hall Inc., 1985.
   Chapter 1 "Artificial Intelligence: What It Is," pp. 3-13. Expanded version of overview of AI contained in 1984 book by same author (see reference 2). Describes "onion model" of AI.

4. Hunt, V. Daniel. Artificial Intelligence & Expert Systems Sourcebook. New York: Chapman and Hall, 1986.
   "Introduction to Artificial Intelligence," pp 1-25. Good overview of AI including "onion model" of artificial intelligence. Includes 200+ page glossary of terms and systems.

5. Hunt, V. Daniel. "The Development of Artificial Intelligence," Signal, April 1987, pp. 59-66.
   Good for brief historical perspective on AI and quick summation of current status; includes one column on Strategic Computing Program.]

6. US Department of the Air Force: HQ Air Force Systems Command (DLAC). Air Force Systems Command Artificial Intelligence Research and Development Plan. Andrews AFB, Maryland, 7 January 1987.

7. US Department of Defense, Defense Advanced Research Projects Agency (DARPA), Strategic Computing Program. New-Generation Computing Technology: A Strategic Plan for its Development and Application to Critical Problems in Defense. Washington, DC, 28 October 1983.

8. Walden, David C. "Successful Applications of Artificial Intelligence," Signal, May 1987, pp. 255-263.
   Includes list of criteria "to evaluate tractability of potential intelligent applications" used by BBN Laboratories, of which article's author is President.

APPENDIX B

LESSON BLOCK: Overview of Artificial Intelligence (continued)

POSSIBLE STUDENT READINGS

[Author's Note: one of the book references by Gevarter or Hunt given under recommended lecture references could be used as a student reading.

9. Daniels, Joel D. "Artificial Intelligence: A Brief Tutorial," Signal, June 1986, pp. 21-23+.

10. Shumaker, Randall P. and Jude Franklin. "Artificial Intelligence in Military Applications," Signal, June 1986, pp. 29-30+.
    Discusses relevant technology with expert systems and natural language understanding called most relevant but then discusses five possible near-term military application areas.

11. Simpson, Robert L., LtCol, USAF. "Applications of AI Capability," Signal, August 1986, pp. 79-86.
    Good readable overview of Strategic Computing Program by DARPA program manager for Machine Intelligence.

12. Stefik, Mark. "Strategic Computing at DARPA: Overview and Assessment," Communications of the ACM, July 1985, pp. 690-704.

ADDITIONAL REFERENCES

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14. Brick, Donald B., James Stark Draper, and H. J. Caulfield. "Computers in the Military and Space Sciences," Computer, October 1984, pp. 250-262.

15. Fitzgerald, Karen and Paul Wallich. "Next-Generation Race Bogs Down," IEEE Spectrum, January 1987, pp. 28-33.

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APPENDIX B

LESSON BLOCK: Overview of Artificial Intelligence (continued)

ADDITIONAL REFERENCES (continued)

19. Rich, Elaine. "The Gradual Expansion of Artificial Intelligence," Computer, May 1984, pp. 4-12.

20. Stenerson, Richard O. "Integrating AI into the Avionics Engineering Environment," Computer, February 1986, pp. 88-91.

21. Voelcker, John. "Software," IEEE Spectrum, January 1988, pp. 38-40.

22. Wallich, Paul. "Software," IEEE Spectrum, January 1987, pp. 36-38.

APPENDIX B

LESSON BLOCK: Expert and Knowledge-Based Systems

RECOMMENDED LESSON REFERENCES

1. Andriole, Stephen J., Editor. Applications in Artificial Intelligence. Princeton, New Jersey: Petrocelli Books, Inc., 1985.
   Part II, pp 39-139 contains four contributed papers. "Knowledge-Based Expert Systems Come of Age" by Duda and Gasching, pp 45-86 is comparatively brief overview and hits major topic, provides "sampling" of systems, includes 36-item bibliography. "Expert Systems: Limited but Powerful" by Gevarter, pp 125-139, includes an explained list of system limitations and table of existing systems showing function, domain, system, and institution that built the system.

2. Barr, Avron and Edward A. Feigenbaum. The Handbook of Artificial Intelligence, Volume I. Stanford, California: HeurisTech Press, 1981.
   Part III, pp 141-222, "Knowledge Representation" presents survey of techniques and then discusses seven different techniques in more detail.

3. Buchanan, Bruce G. "Expert Systems: Working Systems and the Research Literature," Expert Systems, January 1986, pp. 32-51.
   Includes 366 item bibliography of expert systems.

4. Hayes-Roth, Frederick, Donald A. Waterman, and Douglas B. Lenat, Editors. Building Expert Systems. Reading, MA: Addison-Wesley Publishing Company, Inc., 1983.
   Collection of papers presented as chapters. Chapter 1, "Overview of Expert Systems" provides basic characteristics, structure, examples, brief thoughts on where expert systems are going. Chapter 5, "Constructing an Expert System," provides good coverage of knowledge acquisition and steps involved and provides "maxims" for building an expert system. Chapter 8, "Evaluation of Expert Systems: Issues and Case Studies," gives good coverage of issues to be considered and concludes with recommendations on what to keep in mind when building expert systems.

APPENDIX B

LESSON BLOCK: Expert and Knowledge-Based Systems

RECOMMENDED LESSON REFERENCES (continued)

5. Gevarter, William B. Artificial Intelligence: Expert Systems, Computer Vision, and Natural Language Processing. Park Ridge, New Jersey: Noyes Publications, 1984.
   Part B.I, "Expert Systems," pp. 71-86, and Part C.III, "Knowledge Representation," pp. 201-215. Part B.I has block diagram description, characteristics of sample real systems, tables of existing systems, requirements before constructing, summary of state-of-the-art, future trends. Part C-III covers techniques, languages, and issues in knowledge representation.

6. Hunt, V. Daniel. Artificial Intelligence & Expert Systems Sourcebook. New York: Chapman and Hall, 1986.
   "Introduction to Expert Systems," pp. 26-39. Shows block diagram of expert system, flowchart depiction of steps in development of expert system, what a knowledge base is and does, design techniques, and lists of current systems. Book includes 220+ page glossary.

7. US Department of the Air Force: HQ United States Air Force (DCS/Research, Development, and Acquisition). Project Forecast II, Final Report (U), Volume III, Annex C, Technology Opportunities (U) Part I, AFSC-TR-86-006, June 1986. All document requests to HQ AFSC/DLXP, Andrews AFB, Maryland. SECRET - distribution to U.S. Government agencies and their contractors (critical technology). Classified by Multiple Sources. Declassify by OADR.

   Unclassified information only used from this source.

   Contains a section on knowledge-based systems that is unclassified, pages PT 36.01 through PT 36.17.

8. Winston, Patrick H. and Karen A. Prendergast, editors. The AI Business: The Commercial Uses of Artificial Intelligence. Cambridge, Massachusetts: The MIT Press, 1984.
   Part I, "Expert Systems, and Part II, "Work and Play." Examples of real systems, opinions of where business world is going, panel discussions, very "real world" look.

POSSIBLE STUDENT READINGS

9. Feigenbaum, Edward A. and Pamela McCorduck. The Fifth Generation: Artificial Intelligence and Japan's Computer Challenge to the World. Reading, MA: Addison-Wesley Publishing Company, 1983. Part 3, pages 61-95.

APPENDIX B

LESSON BLOCK: Expert and Knowledge-Based Systems (continued)

POSSIBLE STUDENT READINGS (continued)

1Ø. Gevarter. See recommended lesson reference above.

11. Hayes-Roth, Frederick. "Knowledge-Based Expert Systems," Computer, October 1984, pp. 263-273.

12. Hayes-Roth, Frederick. "The Knowledge-Based Expert System: A Tutorial," Computer, September 1984, pp. 11-28.

ADDITIONAL REFERENCES

13. Anderson, Debra and Charles Ortiz. "AALPS: A Knowledge-Based System for Aircraft Loading," IEEE Expert, Volume 2, Number 4 (Winter 1987), pp. 71-79.

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16. Chambers, Alan B. and Nagel, David C. "Pilots of the Future: Human or Computer?," Computer, November 1985, pp. 74-87.

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19. Flynn, John P., Capt., USN and Ted E. Senator. "DARPA Naval Battle Management Applications, " Signal, June 1986, pp. 59-62+.

2Ø. "Knowledge-Based Engineering Systems: Research in Progress," IEEE Software, March 1986, pp. 48-6Ø.

21. Lenat, Douglas B. and Albert Clarkson. "Artificial Intelligence and C3I," Signal, June 1986, pp. 115-119.

22. McTamaney, Louis S. "Mobile Robots: Real-Time Intelligent Control," IEEE Expert, Volume 2, Number 4 (Winter 1987), pp. 55-68. [Author's Note: DoD sponsored or DoD application]

APPENDIX B

LESSON BLOCK: Expert and Knowledge-Based Systems (continued)

ADDITIONAL REFERENCES (continued)

23. Nau, Dana S. "Expert Computer Systems," Computer, February 1983, pp. 63-85.

24. Retelle, John P., LtCol, USAF and Mike Kaul. "The Pilot's Associate - Aerospace Application of Artificial Intelligence," Signal, June 1986, pp. 100-105.

25. Slagle, James R. and Henry Hamburger. "An Expert System for a Resource Allocation Problem," Communications of the ACM, September 1985, pp. 994-1004.

26. Tachmindji, Alexander J. and Edward L. Lafferty. "Artificial Intelligence for Air Force Tactical Planning," Signal, June 1986, pp. 110-114.

27. Williams, Chuck. "Expert Systems, Knowledge Engineering, and AI Tools - An Overview," IEEE Expert, Volume 1, Number 4 (Winter 1986), pp. 66-70.

APPENDIX B

LESSON BLOCK: Natural Language Processing

RECOMMENDED LESSON REFERENCES

1. Andriole, Stephen J., Editor. Applications in Artificial Intelligence. Princeton, New Jersey: Petrocelli Books, Inc., 1985.
   Part III, pp 143-249 contains four contributed papers on natural language processing. "Natural Language Processing: The Field in Perspective" by Hendrix and Sacerdot, pp 149-191, briefly discusses four possible application areas then explores use and limitations but looking at three actual systems, includes 31-item bibliography.

2. Barr, Avron and Edward A. Feigenbaum. The Handbook of Artificial Intelligence, Volume I. Stanford, California: HeurisTech Press, 1981.
   Part IV "Understanding Natural Language" pp. 223-322 discusses mechanics such as grammars, parsing, and text generation and gives seven examples of natural language processing systems.

3. Gevarter, William B. Artificial Intelligence: Expert Systems, Computer Vision, and Natural Language Processing. Park Ridge, New Jersey: Noyes Publications, 1984.
   Part B.III, "Natural Language Processing," pp. 111-126. Not as good as other parts of same book, but overview, table of applications, techniques (pretty technical), table of commercial systems, state-of-the-art (very short), forecast.

POSSIBLE STUDENT READINGS

4. Rich, Elaine. "Natural Language Interfaces," Computer, September 1984, pp. 39-47.

5. Obermeier, Klaus K. "Natural Language Processing," Byte, December 1987, pp. 225-232.

6. Winograd, Terry. "Computer Software for Working with Languages," Scientific American, September 1984, pp. 130-145.

ADDITIONAL REFERENCES

7. Chang, Chin-Liang. Introduction to Artificial Intelligence Techniques. Austin, Texas: JMA Press, Inc., 1985. Chapter 12, Natural Language Processing.

APPENDIX B

LESSON BLOCK: Natural Language Processing (continued)

ADDITIONAL REFERENCES (continued)

8. Hendrix, Gary and Earl Sacerdoti. "Natural-Language Processing, the Field in Perspective," Byte, September 1981, pp. 304+.

9. "Natural Language Resource Guide," Byte, December 1987, p. 233.

10. Winston, Patrick Henry. Artificial Intelligence. Reading, Massachusetts: Addison-Wesley Publishing Company, 1977. Chapter 6, The Meaning of Meaning.

11. Yazdani, Masoud, editor. Artificial Intelligence: Principles and Applications . London: Chapman and Hall, 1986. Chapter 4, Computer Processing of Natural Language.

APPENDIX B

LESSON BLOCK: Machine Vision

RECOMMENDED LESSON REFERENCES

1. Cohen, Paul R. and Edward A. Feigenbaum. The Handbook of Artificial Intelligence, Volume III. Stanford, California: HeurisTech Press, 1982.
   Very extensive coverage. The overview on pages 127-136 gives a very concise look at vision. Pages 136-138 briefly describe the chapter (almost 200 pages). Most of it would be useful for expanding information from other sources as necessary, rather than as a primary source for the lesson.

2. Gevarter, William B. Artificial Intelligence: Expert Systems, Computer Vision, and Natural Language Processing, Part B.II, "Computer Vision," pp. 87-110.
   Block diagram, characteristics of industrial systems, who's doing research, state-of-the-art, applications and future trends.

3. Kent, Ernest W. and Michael O. Shneier. "Eyes for Automatons," IEEE Spectrum, March 1986, pp. 37-45.

4. Myers, Ware. "Industry Begins to Use Visual Pattern Recognition," Computer, May 1980, pp. 21-31.
   Discusses hardware and software needed for machine vision or visual pattern recognition. Describes three major application areas, the industrial requirements for a system and obstacles to applying pattern recognition in industrial applications.

POSSIBLE STUDENT READINGS

5. Fu, K. S. and Rosenfeld, Azriel. "Pattern Recognition and Computer Vision," Computer, October 1984, pp. 274-282.

ADDITIONAL REFERENCES

6. Ballard, Dana H. and Christopher M. Brown. "Vision," Byte, April 1985, pp. 245-261.

7. Browne, Arthur and Leonard Norton-Wayne. Vision and Information Processing for Automation. New York: Plenum Press, 1986.

8. Chang, Chin-Liang. Introduction to Artificial Intelligence Techniques. Austin, Texas: JMA Press, Inc., 1985. Chapter 14, Pictorial Information Processing.

APPENDIX B

LESSON BLOCK: Machine Vision (continued)

ADDITIONAL REFERENCES (continued)

9. Chritchlow, Arthur J. Introduction to Robotics. New York: McMillan Publishing Company, 1985. Chapter 9, Robot Vision.

10. Duda, Richard O. and Peter E. Hart. Pattern Classification and Scene Analysis. New York: John Wiley & Sons, Inc., 1973.

11. Winston, Patrick Henry. Artificial Intelligence. Reading, Massachusetts: Addison-Wesley Publishing Company, 1977. Chapter 8, Points of View on Vision.

12. Yazdani, Masoud, editor. Artificial Intelligence: Principles and Applications . London: Chapman and Hall, 1986. Chapter 6, Computer Vision.

APPENDIX B

LESSON BLOCK: Speech Processing

RECOMMENDED LESSON REFERENCES

1. Barr, Avron and Edward A. Feigenbaum. The Handbook of Artificial Intelligence, Volume I. Stanford, California: HeurisTech Press, 1981.
   Part V "Understanding Spoken Language." Overview and discussion of system architectures in terms of what they have to do. Discusses four example systems.

2. Gevarter, William B. Artificial Intelligence: Expert Systems, Computer Vision, and Natural Language Processing. Park Ridge, New Jersey: Noyes Publications, 1984.
   Part B.IV, "Speech Recognition and Understanding," Part B.V, "Speech Synthesis." Isolated word recognition, continuous speech, speech understanding, state-of-the-art, problems and issues, future trends.

POSSIBLE STUDENT READINGS

3. Welch, John R. "Automatic Speech Recognition - Putting It to Work in Industry," Computer, May 1980, pp. 65-73.
   Describes types of recognition systems (isolated-word, speaker-dependent, connected-word). Gives description of how an automatic speech recognition (ASR) system works. Describes areas of needed improvement, discusses possible industrial applications. At times quite technically detailed but overall readable.

ADDITIONAL REFERENCES

4. Andrews, Harold L. "Speech Processing," Computer, October 1984, pp. 315-324.

5. Chang, Chin-Liang. Introduction to Artificial Intelligence Techniques. Austin, Texas: JMA Press, Inc., 1985. Chapter 13, Speech Processing.

6. Rosch, Winn L. "Voice Recognition: Understanding the Master's Voice," PC Magazine, 27 October 1987, pp. 261-263+.

7. Yazdani, Masoud, editor. Artificial Intelligence: Principles and Applications . London: Chapman and Hall, 1986. Chapter 5, Levels of Representation in Computer Speech synthesis and Recognition.

APPENDIX B

LESSON BLOCK: Planning/Problem Solving/Reasoning

RECOMMENDED LESSON REFERENCES

1. Andriole, Stephen J., Editor. Applications in Artificial Intelligence. Princeton, New Jersey: Petrocelli Books, Inc., 1985.
   Part VI, pp 423-519 contains five contributed papers on problem solving, three of which specifically apply to DoD or are descriptions of DoD applications.

2. Cohen, Paul R. and Edward A. Feigenbaum. The Handbook of Artificial Intelligence, Volume III. Stanford, California: HeurisTech Press, 1982.
   Chapter XIV, Learning and Inductive Inference, and Chapter XV, Planning and Problem Solving. Presents several actual programs and discusses them. Overview of each chapter presents a very brief intro to each topic and then describes chapter.

3. Gevarter, William B. Artificial Intelligence: Expert Systems, Computer Vision, and Natural Language Processing. Park Ridge, New Jersey: Noyes Publications, 1984.
   Part B.VI, "Problem Solving and Planning," pp. 157-177 and Part C.II, "Search-Oriented Automated Problem Solving and Planning Techniques," pp 188-200.

POSSIBLE STUDENT READINGS

See Gevarter reference under lesson references. Use part B.VI which gives a very brief overview of a field still in development but summarizes important information well. Includes a diagram of a planning paradigm.

ADDITIONAL REFERENCES

4. Chang, Chin-Liang. Introduction to Artificial Intelligence Techniques. Austin, Texas: JMA Press, Inc., 1985. Chapter 11, Search Methods.

5. Nilsson, Nils J. Learning Machines. New York: McGraw-Hill Book Company, 1965.

6. Yazdani, Masoud, editor. Artificial Intelligence: Principles and Applications . London: Chapman and Hall, 1986. Chapter 9, Machine Learning.

APPENDIX B

REPRESENTATIVE AI SOFTWARE:

The following citations are not an exhaustive search of available AI software, but are representative examples of what is available that should run on a Zenith Z15Ø-series microcomputer.

1. "Brainware Enterprises Announces," PC AI, Volume 1, Number 4 (Winter 1987), p.14.
   Commercial ad. "KNOWLEDGEBASE (KB) GENERATOR generates an expert system from 'sentence like' input lines to allow the user complete freedom in what the system should express. It can be used in window 'integrated mode' or 'command line mode.' You can 'select goal' or 'find a goal' [through] knowledgebase querying." Appears to build a rule-based expert system. Companion program S.A.R.A.T. version 3.Ø is described as a 'thought' processor. KB GENERATOR is $79.95, S.A.R.A.T is $79.95, available from Brainware Enterprises, 5431 Camden Ave. N., Minneapolis, MN 5543Ø, 612-566-6771.

2. Lewine, Donald A. "First Class Expert Systems Builder," IEEE Software, March 1987, p. 82.
   Expert system builder - creates 'assistant', $495, PC running DOS Version 2.Ø or higher, 256K bytes RAM, two floppy drives; hard disk and 512K bytes RAM recommended. Package is called "First Class," apparently marketed by Profitable Technology, Inc. Based on a commercial ad, latest version is apparently "1st-Class version 3.5" available from Programs in Motion, Inc., 286 Boston Post Road, Wayland, MA Ø1778, (617)-358-7722 or (8ØØ)-872-8812.

3. Shapiro, Ezra. "Moving Toward AI," Byte, August 1987, pp. 263-266.
   Review of "If/Then," by If/Then Solutions, 1 Mallorca Way, Suite 3Ø1, San Francisco, CA 94123, (415)-346-5886), $69.95. Package is built out of Lotus 1-2-3 macros. "Designed as a step-by-step course for anyone who wants to learn the fundamentals of AI programming." Spreadsheets and manual. Not recommended for real AI implementations but good learning tool.

4. "VP-Expert has the Answer," AI Expert, February 1988, inside front page.
   Commercial ad. "VP-Expert lets you create your own Expert Systems, processing the facts and rules you provide to determine the best solution every time." This author has read reviews which indicated this is a good, low cost package for starting in expert systems. Available from Paperback Software, $124.95.

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